

# Misallocation of Capital in a Model of Endogenous Financial Intermediation and Insurance\*

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## Abstract

In this paper we analyze productivity and welfare losses from capital misallocation in a general equilibrium model of occupational choice and endogenous financial intermediation. We study the effects of borrowing and lending, insurance, and risk sharing on the optimal allocation of resources. We find that financial markets together with general equilibrium effects have large impact on entrepreneurs' entry and firm-size decisions. Efficiency gains are increasing in the quality of financial markets, particularly in their ability to alleviate a financing constraint by providing insurance against idiosyncratic risk.

*Keywords:* Financial markets and the macroeconomy; Occupational choice; Personal income and wealth and their distributions

*JEL classification:* E44; J24; D31

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# 1 Introduction

This paper analyzes the role of insurance on the allocation of production inputs in an economy with financial frictions. It is motivated by the increasing evidence that resource misallocation across individual production units may account for a substantial share of the income differences we observe across countries. Hsieh and Klenow (2009) use microdata on manufacturing establishments in China and India to show that reallocating capital and labor to equalize marginal products to the extent observed in the United States could increase manufacturing TFP up to 50 percent in China and 60 percent in India. Banerjee et al. (2003), Banerjee and Munshi (2004), or Alfaro et al. (2008), who study income differences caused by the allocation of resources across heterogeneous firms using data for 80 countries, present evidence that financial market imperfections and misallocation of resources can explain a large part of the TFP differences between rich and poor countries.

These insights have led many researchers to ask why capital is not allocated efficiently across firms. Among possible candidates, frictions in financial markets appear as a natural explanation of resource misallocation.<sup>1</sup> Because of lack of enforcement, commitment or information, high productivity firms are not able to borrow the necessary resources to run their businesses at the optimal size while low productivity firms survive and do not exit the market. In the quantitative macro models, resource reallocation derived from removing inefficiencies in credit markets has large effects on output and measured TFP (see, among others, Buera et al. (2010), Erosa and Hidalgo-Cabrillana (2010), or Moll (2010)).

Using the evidence on financial frictions and entrepreneurial activity presented in the next Section, we build a dynamic general equilibrium model with heterogeneous agents with occupational choice, financial constraints and endogenous financial and insurance markets. Each agent compares the expected value he or she would obtain from being a worker to the expected value of becoming an entrepreneur. A worker receives a wage while an entrepreneur establishes a firm with capital investment, employs other agents as workers, and realizes profit from a decreasing-returns-to-scale production technology. As entrepreneurs must commit resources to their risky business projects, agents with low assets but high skills might be constrained in their entry or firm-size decisions.

The occupational heterogeneity is important as workers (together with the less productive or unconstrained entrepreneurs) lend their assets to entrepreneurs who can use them more productively. Financial intermediation that allocates resources to the most productive use could reduce these financing constraints and increase efficiency. Transferring resources from one agent to another is costly as financial intermediaries need capital and labor to perform these tasks. Therefore, the level of economic activity and the level of financial intermediation are jointly determined.

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<sup>1</sup>For other explanations of resource misallocation see the references in Restuccia and Rogerson (2008).

We calibrate the parameters associated with financial intermediation by matching the share of the financial sector both in GDP and in input markets observed in the data.

Finally, we include the possibility that financial intermediaries also provide insurance in addition to channeling credit. We are interested in analyzing first, the extent to which individual agents endogenously decide to reduce the risk they face, and second, whether and by how much the endogenous insurance markets alleviate the financing constraint and improve the efficient allocation of resources.<sup>2</sup> We simulate four economies that differ in the quality of financial intermediation: we compare allocations and distribution of resources in an economy without financial intermediation to a benchmark economy with borrowing and lending as well as to two insurance economies (with ex-ante insurance and ex-post risk sharing).

Our results provide some answers to a recent paper by Hurst and Lusardi (2004) who challenge the view that personal wealth is a key factor for the decision to become an entrepreneur. Looking at different wealth groups, they estimate that personal wealth is statistically important only for the richest households in the top quintile of the distribution. Since these households are quite wealthy, it is difficult to interpret the importance of wealth for these households as a sign of borrowing constraints. And as the initial capital of many entrants is rather small, it might seem that wealth constraint is not a major deterrent to entrepreneurship.

However, Quadrini (2009) argues that financial constraints may not be a deterrent to becoming an entrepreneur but may affect in important ways the initial operation of a business and its future. This is what we show in our dynamic model. Financial market imperfections keep the initial scale of businesses far below the optimal size. In other words, what plays a crucial role is the impact of financial constraints on the behavior of the entrepreneur after he or she has made the occupational choice.

Second, we find that financial markets do also affect the entry/exit decisions by general equilibrium effects. A well functioning financial intermediation makes personal wealth less relevant when allocating productive capital to managerial skills: the most talented entrepreneurs can enter and operate firms closer to the optimal size. This in turn increases demand for labor and capital. Higher equilibrium wages and interest rates increase the opportunity cost of becoming an entrepreneur for the less talented agents. This further improves the skill composition of entrepreneurs and increases the amount of resources available to the most talented ones. We show in our numerical simulations that this general equilibrium mechanism increase the productivity threshold of entrants: there are fewer but more productive entrepreneurs and the median firm size increases.

Third, borrowing and lending by itself may not be sufficient for the efficient

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<sup>2</sup>For an exogenously imposed risk sharing see Heathcote et al. (2009). Karaivanov et al. (2006) estimate credit market imperfections due to limited liability and moral hazard in Thailand.

allocation of capital to entrepreneurial skills. In our model, entrepreneurs face a financing constraint as they have to pay debts and salaries of workers in each state of the world, namely if the project fails. Poorer entrepreneurs are not willing to run firms close the optimal size if they are exposed to this large income risk. When financial markets also insure entrepreneurs against these potential losses, the allocation of resources becomes much more efficient.

Relative to the economy without financial markets, our benchmark economy with borrowing and lending increases the total factor productivity by 19.4% and welfare by 17.5%. Both insurance and risk sharing increase efficiency by additional 7% and welfare by 3%. Increased competition among entrepreneurs reduces their profits. All the welfare gains apply to workers who benefit from higher equilibrium wages and the possibility to receive return on their savings.

Overall, we find that higher quality of financial markets increases efficiency, improves average welfare as well as reduces inequality. We show that the efficiency gains operate through alleviated financing constraints. This is because, conditional on a level of wealth, high skill and high marginal productivity entrepreneurs can enter and/or expand their firms, while general equilibrium effects provide incentives for low skill entrepreneurs to reduce their firms or exit and become workers.

The paper is organized as follows. Section 2 summarizes the relationship between financial intermediation and entrepreneurship in the United States. In the following three sections we describe four economies that differ in the financial intermediation services they provide. First, we develop the benchmark economy with borrowing and lending intermediated by a competitive endogenous banking sector. We then add insurance markets that offer actuarially fair risk sharing and insurance contracts. Fourth, for efficiency comparisons we present an economy where the financial markets are missing. In Section 6 we characterize the effects of financial markets on entrepreneurial decisions. Results of numerical simulations are presented in Section 7. Section 8 concludes.

## 2 Entrepreneurial Activity in the United States

First, we will briefly describe the relationship between financial intermediation and entrepreneurship in the United States. We follow Gentry and Hubbard (2000) and define an entrepreneur as someone who combines upfront business investment with entrepreneurial skill to obtain the chance of earning economic profits. According to the Survey of Consumer Finances (SCF 1989), 8.7% households report active business assets greater than \$5,000 (9.5% report business assets greater than \$1,000). Similarly, in the Panel Study of Income Dynamics (PSID 1994), 10.4% of families own a business or have a financial interest in some business enterprise. The following paragraphs relate the wealth and income data to occupational choice in the United States.

De Nardi et al. (2007) document that U.S. entrepreneurs are characterized by their high propensity to accumulate capital, risk taking, and committing skills and resources to their businesses. The Gini coefficient for family wealth is between 0.78 and 0.84, depending on the year and survey (PSID and SCF, respectively). The Gini coefficient for family income is 0.45 in the PSID and 0.54 in the SCF. In the PSID, the top 1 percent of families owns around 29% of the total household wealth and around 8% of the total income. The top 5 percent owns already 50% of the wealth and receives 20% of the income. Finally, the top decile owns more than 60% of the wealth and receives more than 32% of the income. The percentage of business families increases in higher wealth classes: Quadrini (1999a) documents that about half of all families in the top 5% are business families. At the same time, the concentration of wealth among business families is not purely explained by the concentration of income. Quadrini (1999b) and Gentry and Hubbard (2000) report that entrepreneurs are wealthy because they not only earn more income but also save relatively more than workers. Entrepreneurs, being such a small fraction of the population, receive 22% of the total income and own 40% of the total wealth. The ratio of wealth to income is about twice as large for business families (6.77 versus 2.94).

Entrepreneurial portfolios are very undiversified. Gentry and Hubbard (2000) find that active businesses account for 42% of entrepreneurs' assets (even in the top wealth classes). Also, entrepreneurs hold relatively less of their wealth in liquid assets. In the survey of Characteristics of Business Owners (2002), seventy percent of the owners of employer respondent firms reported that their business was their primary source of income. The turnover of business families is substantial. Entrepreneurial income is more volatile than the labor income of workers. Heaton and Lucas (2000) find that the median standard deviation of the growth rate of nonfarm proprietary income is 64% annually while the median standard deviation of the growth rate of real wage income is only 35% annually. Evans (1987) estimates that the exit rate is around 4.5% (the rate for entrepreneurs with one year of tenure is much higher, see Quadrini (1999a)). Not only face entrepreneurs high risk in their occupation, it also has a future value compared to initial income: Hamilton (2000) finds evidence that most entrepreneurs enter and persist in business despite the fact that they have lower initial earnings in paid employment, with a median earnings differential of 35 percent.

Available evidence suggests that entrepreneurs are constrained by their wealth. Based on the National Longitudinal Survey, Evans and Leighton (1989) find that men with greater assets are more likely to become self-employed all else being equal. They estimate in their model that entrepreneurs can borrow up to 50% of their current assets.<sup>3</sup> The Federal Reserve Survey of Terms of Business Lending

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<sup>3</sup>In an important field study Paulson and Townsend (2002) find that two-thirds of Thai business households are financially constrained, mostly due to limited commitment problem faced by the poor entrepreneurs.

reveals that small loans are more often secured by collateral.<sup>4</sup> Small firms pay fewer dividends, take on more debt, and invest more. In terms of the aggregate value of small firm debt, almost 90% of credit comes from traditional sources, mostly lines of credit and loans. Between 65 percent and 79 percent of entrepreneurs started their own business and almost half of entrepreneurs use their own or their family's savings. Fazzari et al. (1988) report that internal finance in the form of retained earnings generates the majority of net funds for firms of all size categories: the average retention ratio is largest for small firms (80%) and lowest for the largest firms (50%). Finally, Eisner (1978) finds that the timing of investment in small firms is more sensitive to profits than it is in large firms.

At the same time, entrepreneurial activity is a very important feature of the U.S. economy. Small firms play an important role in innovation, technological change and productivity growth. Davis et al. (1996) show that the rates of job creation and job destruction in U.S. manufacturing firms decrease in firm size and that, conditional on the initial size, small firms grow faster than large firms. In the 1990s, small businesses employed more than half of the workforce and created three-fourths of the new jobs.

The benchmark model in the next Section attempts to replicate this list of data on entrepreneurial activity in the United States. Motivated by the above empirical regularities, agents will be identified by their accumulated level of assets and entrepreneurial ability. In the presence of financial constraints, occupational choice and entrepreneurial decisions will be functions of this individual state and equilibrium prices.

### 3 The Economy

In this paper we describe four economies that differ in financial intermediation services they provide. In this Section we develop the benchmark economy with borrowing and lending intermediated by a competitive endogenous banking sector.

There is a continuum of agents with mass one. These individuals differ in the amount of accumulated assets and their talent (productivity). Each agent decides whether to allocate his talent to be an entrepreneur and establish a firm or to be a worker and work for an entrepreneur. We assume that there exists a financial

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<sup>4</sup>In 2000, of all commercial and industrial loans in the United States, 83% required collateral for loans smaller than \$99,000, 74% for loans smaller than \$1 million, 46.9% for loans smaller than \$10 million, and only 31.7% for loans greater than \$10 million. In Europe, the 2010 ECB survey of small and medium size enterprises (SME) shows that around 60% of small and medium size enterprises (SME) use at least one source of debt financing. The most prevalent source of debt financing has been the bank: 30% of companies have used bank overdraft facilities or a credit line and 26% have received a bank loan. Lack of collateral is the most significant obstacle for establishing a firm, with about 15% of loans were fully rejected. See De Nardi et al. (2007) for a similar evidence for the United States.

intermediation sector that provides credit services.

Each agent is endowed with a unit of time and evaluates streams of consumption  $c$  with a utility function

$$E \left[ \sum_{t=0}^{\infty} \beta^t u(c_t) \right],$$

where  $\beta \in (0, 1)$  and  $u : \mathfrak{R}_+ \rightarrow \mathfrak{R}$  is a bounded, strictly increasing, strictly concave, and twice differentiable continuous function that satisfies the Inada conditions.

The timing of events is as follows. At the beginning of every period, agents are identified by a level of accumulated assets  $a \in A = [0, \infty)$  and by an idiosyncratic productivity shock  $z \in Z = [\underline{z}, \bar{z}]$ . This productivity level is carried from the previous period and represents a *signal* for the effective productivity the agent will have later in the period when production takes place,  $z' \in Z$ . Given  $a$  and the signal  $z$ , first, each agent makes the occupational choice and decides whether to become a worker or an entrepreneur. Workers deposit their assets at the financial intermediaries and offer their labor services in the market. Entrepreneurs decide how much capital and labor to use in production. Importantly, they have to commit capital and labor before their effective productivity shock is realized. This feature of the model reflects the riskiness of entrepreneurial occupation. In the literature, entrepreneurs usually do not face any risk from running their businesses as their occupational and input decisions are made *after* the productivity shock is observed (for example Cagetti and De Nardi (2006), Meh (2008), or Restuccia and Rogerson (2008)).

An agent who decides to be an entrepreneur and commits his capital and labor input, will draw his productivity level from a Markov process with a monotone transition function  $Q$  that satisfies the Feller property and the mixing condition. If an agent decides to be a worker, he will draw his effective skill,  $z'$ , from a distribution  $\psi$ , and will obtain labor income equal to  $z'w$  where  $w$  is the equilibrium wage.

At the end of the period, the effective productivity shock of each agent  $z'$  is realized, production at firms takes place, workers are paid their wages and entrepreneurs realize profits or losses. Finally, each agent decides how much to consume  $c$  and the amount of savings  $a'$ . The effective productivity shock  $z'$  is carried to the next period as the signal for future productivity shocks. All assets depreciate at the rate  $\delta \in (0, 1)$ .

Banks are in the business of intermediating credit. The supply of credit comes from depositors, i.e. all workers as well as entrepreneurs with assets in excess of their capital needs. The demand for credit is from entrepreneurs whose efficient size of firm in terms of capital is larger than their accumulated assets. The intermediation technology is represented by an aggregate constant-returns-to-scale production function that transforms the deposits of workers and non-borrowing entrepreneurs into loans for borrowing entrepreneurs. Intermediation is costly as the

zero-profit representative bank employs capital  $K^L$  and labor  $N^L$ . The equilibrium interest rate on deposits,  $r^D$ , and loans,  $r^L$ , will be described below.

At the stationary equilibrium, the problem of an agent who enters the period with the pair  $(a, z)$  can be summarized by the value function

$$v(a, z) = \max \left\{ \int v^W(a, z') \psi(dz'), \max_{k, n} \int v^E(a, z') Q(z, dz') \right\}$$

$$v^i(a, z') = \max_{c, a'} \{u(c) + \beta v(a', z')\}, \quad (1)$$

where the superscript  $W$  denotes a worker and  $E$  an entrepreneur, with  $i = W, E$ . Notice again that entrepreneurs must commit capital and labor inputs before the effective productivity shock  $z'$  is known.

### 3.1 A Worker's Problem

If an agent with assets  $a$  and a signal ability shock  $z$  decides to be a worker, his budget constraint is

$$c + a' \leq (1 - \delta)a + \pi^W(a, z') = (1 + r^D)a + wz', \quad (2)$$

with income defined as  $\pi^W(a, z') = (r^D + \delta)a + wz'$ . The worker deposits all his assets at the bank for an interest rate  $r^D$  and receives a wage  $w$ .

### 3.2 An Entrepreneur's Problem

An entrepreneur who uses capital  $k$  and labor  $n$  and draws an effective productivity shock  $z'$ , produces according a production function

$$y = z' f(k, n) = z' (k^\alpha n^{1-\alpha})^\theta, \quad (3)$$

where  $\alpha \in (0, 1)$  and  $\theta < 1$ . The production function exhibits decreasing returns to scale which, as in Lucas (1978), can be thought of as capturing the presence of decreasing returns to managerial control. We assume hired labor  $n$  consists of a pool of perfectly diversified workers with the average workers' skill normalized to one. The budget constraint for an entrepreneur is

$$c + a' \leq (1 - \delta)a + \pi(a, z'|z), \quad (4)$$

where  $\pi$  is the profit that depends on whether the entrepreneur is a depositor or a borrower. Entrepreneurs who have enough assets to finance their projects at the desired level without borrowing from the bank, i.e.  $a \geq k(a, z)$ , are net depositors and receive  $(r^D + \delta)(a - k)$  from the bank. On the other hand, those entrepreneurs who need to borrow to obtain additional capital for their projects, i.e.,



entrepreneurs for whom  $k(a, z) \geq a$ , are net borrowers and must pay  $(r^L + \delta)(k - a)$  to the bank. Combining the profit functions for both types of entrepreneurs,

$$\pi(a, z'|z) = z' (k^\alpha n^{1-\alpha})^\theta - wn + (r^D + \delta) \max\{0, a - k\} - (r^L + \delta) \max\{0, k - a\}.$$

We assume there is no possibility of default on bank loans and wages of hired workers. Also, we abstract from a fixed cost associated with operating a business modeled in Hopenhayn and Rogerson (1993), among others, and think of the endogenous opportunity cost of forgone equilibrium wages/profits as the main determinant of entry/exit outcomes that arise from comparing the expected present discounted value of each occupation.

### 3.3 The Financing Constraint

The specification of the Inada-type utility function together with the uncertainty in entrepreneurial profits imply that agents with a low level of accumulated assets may be constrained with respect to the size of their entrepreneurial project. In particular, the total entrepreneurial income must guarantee a nonnegative consumption for all possible realizations of profits. Therefore, an entrepreneurs must have a sufficient level of accumulated assets to satisfy the following constraint<sup>5</sup>

$$(1 - \delta)a + \pi(a, z') \geq 0 \text{ for all } z' \in Z. \quad (5)$$

Since in each period  $Q(z, \{z\}) > 0$  for all  $z \in Z$ , this ex-post financing constraint must be satisfied for the lowest effective ability shock  $\underline{z} = 0$ , that is

$$(1 - \delta)a + \pi(a, \underline{z}) \geq 0.$$

For entrepreneurs with a high signal  $z$ , that is for those who would like to borrow and hire many workers,  $\pi(a, \underline{z})$  represents a large loss they must finance from their accumulated assets. This potential loss might prevent those with low savings to run a project at its efficient size. At the same time, running a very small firm might decrease the expected profits below the opportunity cost of running the project in the first place.<sup>6</sup> Therefore, the financing constraint may have important allocation effects on entry and especially on the firm size decisions.

### 3.4 The Financial Intermediary

In the benchmark economy, financial intermediation consists of banks that accept deposits and provide loans to entrepreneurs. Because of perfect competition in the industry and the constant returns to scale technology for loans, banks earn zero

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<sup>5</sup>This constraint can also be motivated by limited enforceability of contracts.

<sup>6</sup>The main opportunity cost is the forgone equilibrium wage from being a worker. The future value of a project will be discussed in Section 6.

profits and are modeled as a representative bank. The bank owns no resources and needs to finance all its operations from deposits. Total deposits from workers and depositing entrepreneurs are

$$D = \int_{E \times W} \max\{0, a - k\} \lambda(da \times dz).$$

Financial intermediation and insurance is costly, requiring capital and labor inputs  $(K^L, N^L)$ . Deposits are used to provide loans  $L$  to entrepreneurs as well as the capital input for the bank,

$$D = L + K^L. \quad (6)$$

We assume that the bank and entrepreneurs hire workers in the same labor market at the same equilibrium wage. The problem of the bank is to choose its inputs  $(K^L, N^L)$  to maximize profits,

$$\Pi^L = (r^L - r^D) L - (r^D + \delta) K^L - wN^L,$$

subject to the loan production technology

$$L = Z^B (K^L)^{\alpha^B} (N^L)^{1-\alpha^B},$$

where  $Z^B$  is a technology parameter and  $\alpha^B \in (0, 1)$ . We assume banks lend to a perfectly diversified pool of entrepreneurs and as there is no default, they do not face any risk.

### 3.5 Stationary equilibrium

At the aggregate level, the equilibrium outcome of these decisions is a probability measure  $\lambda$  that determines the density over agents' individual states  $(a, z)$ , with a law of motion

$$\lambda'(\mathcal{A}', \mathcal{Z}') = \int_S \Delta(z, dz') \lambda(da \times dz),$$

where  $S = \{(a, z') : a'(a, z') \in \mathcal{A}' \text{ and } z' \in \mathcal{Z}'\}$  and  $\Delta$  is a transition selector

$$\Delta(z, dz') \equiv \psi(dz')|_W + Q(z, dz')|_E,$$

that determines the end of period productivity from the beginning of period productivity for each occupation. The measure of agents with next period's state in the set  $(\mathcal{A}', \mathcal{Z}')$  consists of agents whose skills evolve to the set  $\mathcal{Z}'$  and whose savings belong to the set  $\mathcal{A}'$ .

The concept of stationary equilibria requires that assets supplied by all agents equal the amount of capital demanded by the entrepreneurs and banks, that labor supply by workers equals the labor hired by entrepreneurs and banks, and that all allocations be feasible for a time invariant probability measure  $\lambda$ ,

$$\lambda(\mathcal{A}', \mathcal{Z}') = \int_S \Delta(z, dz') \lambda(da \times dz),$$

**Definition 1** *A stationary recursive equilibrium with borrowing and lending is constant prices  $(r^D, r^L, w)$ , value functions  $(v, v^W, v^E)$ , policy functions  $(k, n, c, a')$ , a probability measure  $\lambda$ , transition selector  $\Delta(z, dz')$ , and aggregate levels  $(A, K^L, D, L, N, N^L, Y)$ , such that*

1. *at given prices the policy functions solve the optimization problem of each agent  $(a, z)$ ;*
2. *at given prices, the aggregate levels  $(K^L, N^L)$  maximize profits for the representative bank;*
3. *the probability measure  $\lambda$  is time invariant;*
4. *prices are such that markets clear: these are the market for deposits,*

$$D = \int \max\{0, a - k\} \lambda(da \times dz) = L + K^L,$$

*the loans market,*

$$L = Z^B (K^L)^{\alpha^B} (N^L)^{1-\alpha^B} = \int_E \max\{0, k - a\} \lambda(da \times dz),$$

*and the labor market,*

$$N = \int_W z' \psi(dz') \lambda(da \times dz) = \int_E n(a, z) \lambda(da \times dz) + N^L,$$

*with*

$$\int_W \lambda(da \times dz) + \int_E \lambda(da \times dz) = 1;$$

5. *the aggregate feasibility constraint holds at equality: for goods*

$$\begin{aligned} \int \{c(a, z') + \delta a'(a, z')\} \Delta(z, dz') \lambda(da \times dz) &= \\ &= \int z' f(k(a, z), n(a, z)) Q(z, dz') \lambda(da \times dz) = Y, \end{aligned}$$

*and assets,*

$$A = \int a \lambda(da \times dz) = \int_E k(a, z) \lambda(da \times dz) + K^L.$$

## 4 Insurance and Risk Sharing

Contracts that could alleviate the financing constraint might have important efficiency effects if they allow the more talented entrepreneurs to enter and/or run their firms at a more efficient size. In this Section we describe two types of such contracts, risk sharing and insurance. Entrepreneurs will be able to choose the degree of profit uncertainty they want to bear. We assume that all allocations are fully observable and contracts fully enforceable. We discuss asymmetric information and the moral hazard and the adverse selection problem in Section 7.

## 4.1 Ex-Post Risk Sharing

An ex-post risk sharing contract allows entrepreneurs to insure against the profit risk by receiving transfers from the pool of realized profits of other entrepreneurs. These transfers are administered by the financial sector. As the risk sharing contracts are actuarially fair and the insurer has zero profit, we include these services with the representative bank. Similarly to borrowing and lending, the transfer technology is costly in terms of capital and labor. To pay for these inputs, the bank requires a price  $p$  to be paid per unit of each transfer made.

To illustrate a simple case of a full risk sharing, imagine a contract that always delivers the expected profits  $E[\pi(a, z')|z]$  to each entrepreneur in any state of the world. That is, in the case of a profit realization  $\pi(a, z') < E[\pi(a, z')|z]$  an entrepreneur receives a transfer  $E[\pi(a, z')|z] - \pi(a, z')$ , and sends away a transfer if the profit realization is above the expected value. Then his budget constraint is

$$c + a' \leq (1 - \delta)a + E[\pi(a, z')|z] - p |E[\pi(a, z')|z] - \pi(a, z')|.$$

This example of full risk sharing would impose an extreme degree of insurance on entrepreneurs who might prefer less or even no risk sharing. In our economy, we allow each entrepreneur to choose a fraction  $x \in [0, 1]$  of profits he wants to insure,

$$v(a, z) = \max \left\{ \int v^W(a, z') \psi(dz'), \max_{k, n, x} \int v^E(a, z') Q(z, dz') \right\}.$$

In this case, the entrepreneur's after-transfer profit  $x E[\pi(a, z')|z] + (1 - x)\pi(a, z')$  leads to a budget constraint

$$c + a' \leq (1 - \delta)a + x E[\pi(a, z')|z] + (1 - x)\pi(a, z') - xp |E[\pi(a, z')|z] - \pi(a, z')|.$$

The ex-post financing constraint now becomes

$$(1 - \delta)a + x E[\pi(a, z')|z] + (1 - x)\pi(a, z') - xp |E[\pi(a, z')|z] - \pi(a, z')| \geq 0, \quad (7)$$

for all  $z' \in Z$ .

We show in Section 6 that the financing constraint is less binding than in the benchmark economy. An important feature of the risk sharing is that transfers are received/paid in all states of the world, including the good states in which profits are high. Thus successful entrepreneurs who might want to invest heavily into their business have less income than without risk sharing or with a standard insurance contract described below.

With risk sharing, the representative bank now intermediates credit between agents as well as provides insurance services. Deposits are used for loans  $L$  and both capital inputs of the bank,  $K^L$  and  $K^I$ ,

$$D = L + K^L + K^I.$$

In providing insurance, the bank chooses inputs  $(K^I, N^I)$  to maximize profits,

$$\Pi^I = pI - (r^D + \delta) K^I - wN^I, \quad (8)$$

where  $I$  is the total amount of risk sharing transfers (to those who have less than expected profits as well from those who have more than expected profits),

$$I = x \int |E[\pi(a, z')|z] - \pi(a, z'|z)| Q(z, dz') \lambda(da \times dz).$$

We assume a the same Cobb-Douglas technology for the risk-sharing services

$$I = Z^B (K^I)^{\alpha^B} (N^I)^{1-\alpha^B}. \quad (9)$$

Because of perfect competition in the insurance industry and the constant returns to scale assumption for the risk sharing technology, insurance earns zero profits. Both parts of the bank, the borrowing/lending and insurance services, take prices as well as the total amount of deposits as given when making production decisions.

## 4.2 Ex-Ante Insurance

An ex-ante insurance contract insures an entrepreneur's profits in a bad state. That is, if the realized profit  $\pi(a, z') < \underline{\pi}$ , the entrepreneur receives an insurance payment  $\underline{\pi} - \pi(a, z')$ , and zero otherwise. As the contract provides for actuarially fair insurance, the insurer has zero profits and is again a part of the representative bank. The insurance technology is costly, paid for by a price  $p$  proportional to the expected insurance payments (insurance premium).

We allow each entrepreneur to choose the insurance level as an amount of profits  $\underline{\pi} \in (-\infty, E[\pi(a, z')|z])$  below which he receives the insurance payment,

$$v(a, z) = \max \left\{ \int v^W(a, z') \psi(dz'), \max_{k, n, \underline{\pi}} \int v^E(a, z') Q(z, dz') \right\}.$$

The insurance premium is paid ex-ante (when inputs are chosen, i.e. before profits are realized) and must be financed from accumulated assets of the entrepreneur. Thus the insurance premium payment represents an ex-ante financing constraint and reduces the amount of assets available for investment in the project to  $\tilde{a} < a$ . As the amount of resources paid for insurance and the project's size are chosen jointly, they represent a fixed point that depends on the wealth and skill of the entrepreneur. The ex-ante insurance premium constraint is

$$\tilde{a} \equiv a - (1 + p) \int \max \{0, \underline{\pi} - \pi(\tilde{a}, z'|z)\} Q(z, dz') \geq 0, \quad (10)$$

where the profit is

$$\pi(\tilde{a}, z'|z) = z'(k^\alpha n^{1-\alpha})^\theta - wn + (r^D + \delta) \max\{0, \tilde{a} - k\} - (r^L + \delta) \max\{0, k - \tilde{a}\}.$$

The budget constraint becomes

$$c + a' \leq (1 - \delta)a + \max \{\underline{\pi}, \pi(\tilde{a}, z')\} - (1 + p) \int \max \{0, \underline{\pi} - \pi(\tilde{a}, z'|z)\} Q(z, dz'),$$

with the ex-post financing constraint

$$(1 - \delta)a + \max \{\underline{\pi}, \pi(\tilde{a}, z')\} - (1 + p) \int \max \{0, \underline{\pi} - \pi(\tilde{a}, z'|z)\} Q(z, dz') \geq 0, \quad (11)$$

for all  $z' \in Z$ .

Compared to the risk sharing contract, an insurance contract can provide the same level of insurance without taking resources from entrepreneurs when profits are high. We show in Section 6 that it relaxes the ex-post financing constraint but it adds a new, ex-ante financing constraint required for the insurance premium. Although the amount of the premium is chosen by each entrepreneur, the ex-ante premium constraint might limit the entry into entrepreneurship or the size of business firms for poor agents.

As with risk sharing, the insurance services require inputs  $(K^I, N^I)$  that maximize profits (8), where  $I$  is now the total amount of insurance payments,

$$I = \int \max \{0, \underline{\pi} - \pi(a, z'|z)\} Q(z, dz') \lambda(da \times dz).$$

We assume the same technology to produce insurance transfers as in equation (9).

Again, because of perfect competition in the insurance industry and the constant returns to scale production function, insurance services earn zero profits. We also assume in this case that they take prices as well as the total amount of deposits as given when making production decisions.

### 4.3 Stationary Equilibrium with Insurance

The definition of a stationary recursive equilibrium with risk sharing or insurance now also includes the insurance sector, the price of insurance, and the insurance decisions of entrepreneurs.

**Definition 2** *A stationary recursive equilibrium with borrowing and lending and risk sharing/insurance is constant prices  $(r^D, r^L, w, p)$ , value functions  $(v, v^W, v^E)$ , policy functions  $(k, n, c, a')$  and either insurance policy  $x$  or  $\underline{\pi}$ , a probability measure  $\lambda$ , transition selector  $\Delta(z, dz')$ , and aggregate levels  $(A, K^L, K^I, D, L, N, N^L, N^I, I, Y)$ , such that*

1. *at given prices the policy functions solve the optimization problem of each agent  $(a, z)$ ;*

2. at given prices, the aggregate levels  $(K^L, N^L)$  and  $(K^I, N^I)$  maximize profits for the representative bank and insurance company;
3. the probability measure  $\lambda$  is time invariant;
4. prices are such that markets clear: these are the market for deposits,

$$D = \int \max\{0, a - k\} \lambda(da \times dz) = L + K^L + K^I,$$

the loans market,

$$L = Z^B (K^L)^{\alpha^B} (N^L)^{1-\alpha^B} = \int_E \max\{0, k - a\} \lambda(da \times dz),$$

the risk-sharing market/insurance,

$$I = Z^B (K^I)^{\alpha^B} (N^I)^{1-\alpha^B},$$

where  $I$  is either

$$I = x(a, z) \int |E[\pi(a, z')|z] - \pi(a, z'|z)| Q(z, dz') \lambda(da \times dz),$$

or

$$I = \int \max\{0, \pi(a, z) - \pi(a, z'|z)\} Q(z, dz') \lambda(da \times dz),$$

and the labor market,

$$N = \int_W z' \psi(dz') \lambda(da \times dz) = \int_E n(a, z) \lambda(da \times dz) + N^L,$$

with

$$\int_W \lambda(da \times dz) + \int_E \lambda(da \times dz) = 1;$$

5. the aggregate feasibility constraint holds at equality: for goods

$$\begin{aligned} \int \{c(a, z') + \delta a'(a, z')\} \Delta(z, dz') \lambda(da \times dz) &= \\ &= \int z' f(k(a, z), n(a, z)) Q(z, dz') \lambda(da \times dz) = Y, \end{aligned}$$

and assets

$$A = \int a \lambda(da \times dz) = \int_E k(a, z) \lambda(da \times dz) + K^L + K^I.$$

## 5 The Economy without Financial Intermediation

Finally, we include a description of an economy without financial intermediation. All agents have access to a storage technology that does not bring any return. Each entrepreneur must finance his or her project from accumulated assets. Otherwise, the structure of this economy is identical to the previous ones. In particular, there still exists a labor market where workers can be hired at an equilibrium wage  $w$ . Entrepreneurs have access to the same production technology and assets depreciate in production at a rate  $\delta \in (0, 1)$ .

A worker now faces a budget constraint

$$c + a' \leq a + wz'.$$

An entrepreneur has a budget constraint

$$c + a' \leq a + \pi(a, z'|z),$$

with profits equal to

$$\pi(a, z'|z) = z' (k^\alpha n^{1-\alpha})^\theta - \delta k - wn.$$

Without financial intermediation, there is a no-borrowing constraint

$$k \leq a.$$

The financing constraint can be written, for  $z' = \underline{z} = 0$ ,

$$(1 - \delta)a - \delta(k - a) - wn \geq 0, \tag{12}$$

which is the same as for the benchmark economy with a zero interest rate (and different equilibrium wage).

The definition of the stationary recursive competitive equilibrium is similar to that of the economy with financial intermediation except for the market clearing condition in the asset market. If the equilibrium exists, i.e., if there is a positive fraction of workers (entrepreneurs), the total amount of capital used in production is strictly smaller than the total amount of assets in the economy,  $K < A$ .

## 6 Characterization of Entrepreneurial Decisions

The occupational choice of an agent is based on the comparison of the expected present discounted value of each career. The following two assumptions guarantee the existence of a stationary recursive equilibrium with a positive fraction of the population in each occupation.



**Assumption 1** *The signal ability shock  $\bar{z}$  is such that there exists an asset level  $a^s$  for which*

$$\int v^W(a, z') \psi(dz') \leq \int v^E(a, z') Q(\bar{z}, dz') \text{ for all } a \geq a^s.$$

**Assumption 2** *The signal ability shock  $\underline{z}$  is such that*

$$\int v^W(a, z') \psi(dz') \geq \int v^E(a, z') Q(\underline{z}, dz') \text{ for all } a \in A.$$

Both assumptions are related to the opportunity cost of each occupation. The first assumption requires that there be a shock sufficiently high so that agents with assets greater than a switching level  $a^s$  become entrepreneurs: the expected value of entrepreneurship is greater than the expected value of choosing to work for a wage. Vice versa, the second assumption requires a shock sufficiently low so that agents with such a signal prefer to be workers.

The properties of value functions for each occupation follow the analysis in Bohacek (2006) and Stokey et al. (1989). The value function of each occupation,  $v^I(a, z')$ , is strictly increasing in each argument since the utility function is strictly increasing and strictly concave and the constraint set is strictly increasing in assets and the effective ability shock.

The expected value function of workers is independent of  $z$  and an increasing and continuous function of  $a$ . Due to the monotonicity of the transition matrix  $Q$ , the expected value function of entrepreneurs is an increasing and continuous function of both  $a$  and  $z$ . Finally, the value function  $v(a, z)$  is non-decreasing in  $z$  and strictly increasing in  $a$ .<sup>7</sup>

#### INSERT FIGURE 1

Figure 1 displays values related to the occupational decision of agents with three levels of signal: low,  $z_L$ , medium,  $z_M$ , and high,  $z_H$ . As the value function of entrepreneurs is increasing in and that of workers independent of the signal ability shock, it can be easily shown that for each  $z$  there is either none or at most one switching level of assets  $a^s(z)$  decreasing in  $z$ . For given prices, all agents below  $a^s(z_H)$  are workers. Agents with the high signal ability shock switch to entrepreneurship early at  $a^s(z_H)$ , agents with the medium signal shock at  $a^s(z_M)$ , while agents with the lowest skill  $z_L$  never become entrepreneurs, regardless of their wealth. Thus the signal  $z_H$  satisfies Assumption 1 and the signal  $z_L$  satisfies Assumption 2.

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<sup>7</sup>The value function  $v(a, z)$ —the outer envelope for the value functions at each shock level—may not be a concave function even if the value functions of workers and entrepreneurs are. Gomes et al. (2001) analyze a model of unemployment with a similar property. The operator on the value function satisfies the Blackwell's sufficient conditions for a contraction mapping. In this paper, we do not explore possible gains from randomization.

## 6.1 The Future Value of Entrepreneurship

The experience aspect contained in the monotone Markov process has important implications for the investment decisions of entering entrepreneurs. Contrary to the static model in Lucas (1978), where agents only consider the current expected incomes, it is the expected discounted present value of each career that determines an agent's occupational decision.

For a given level of signal ability shock  $z \in Z$ , an agent with assets at the switching level  $a^s(z)$  is indifferent between working and undertaking an entrepreneurial project. Therefore, it must be the case that

$$\int v^W(a^s(z), z') \psi(dz') = \int v^E(a^s(z), z') Q(z, dz'). \quad (13)$$

The first order intertemporal condition for any asset level  $a$  and any realized effective ability shock  $z'$  is just  $u_c(c(a, z')) = \beta v_a(a'(a, z'), z')$  as there is no uncertainty about the agent's next period state. Using the usual envelope conditions and assuming interior solutions, the condition (13) can be rewritten, dropping the term  $(1+r)\beta$  on both sides, as

$$\int v_a(a'(a^s(z), z'), z') \psi(dz') = \int v_a(a'(a^s(z), z'), z') Q(z, dz').$$

Entrepreneurship has a future value if the transition process  $Q$  is sufficiently persistent,  $\int z' \psi(dz') < \int z' Q(z, dz')$ . In other words, the marginal entrepreneurs are willing to sacrifice current consumption for having the opportunity to begin their business career that brings high returns only in the future. They invest a large share of their income and wealth in order to relax the credit constraint and to run their firm at the optimal size. For such agents the expected current income from business might be lower than the current expected wage. Because the financing constraint prevents the entrepreneur from running the firm at the optimal size, the above inequality might hold for several initial periods of entrepreneurship.<sup>8</sup>

## 6.2 Entrepreneurial Decisions

It is easy to show that in the three economies with financial intermediation, all entrepreneurs use the optimal capital-labor ratio

$$\kappa \equiv \frac{k}{n} = \left( \frac{\alpha}{1-\alpha} \right) \left( \frac{w}{r+\delta} \right)$$

where  $r$  equals  $r^L$  or  $r^D$  depending on whether we are considering, respectively, a borrowing or depositing entrepreneur. Because  $r^L > r^D$ , depositing entrepreneurs run more capital intensive firms than those who borrow.

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<sup>8</sup>In the search model with occupational choice by Gomes et al. (2001), consumption of searchers similarly decreases compared to workers who keep their jobs.

Because  $Q(z, \{z\}) > 0$  for all  $z \in Z$ , the financing constraint must be satisfied for the lowest effective ability shock  $\underline{z} = 0$ . For the economy with borrowing and lending only, the financing constraint of a borrowing entrepreneur is

$$(1 - \delta)a - wn - (r^L + \delta)(k - a) \geq 0.$$

Using the optimal capital-labor ratio

$$k \leq \alpha \left( \frac{1 + r^L}{r^L + \delta} \right) a. \quad (14)$$

This is a linear expression linking accumulated assets with the maximum level of capital satisfying the financing constraint. For the usual values of the parameters  $\alpha$  and  $\delta$  and the loan rate  $r^L$ ,

$$\alpha \left( \frac{1 + r^L}{r^L + \delta} \right) > 1,$$

so that the maximum level of capital as a function of assets lies above the 45 degree line. Depositing entrepreneurs face a similar constraint with the deposit rate  $r^D$  instead of  $r^L$ . However, as depositing entrepreneurs always satisfy  $k < a$ , the financing constraint applies only to the borrowing entrepreneurs.

## INSERT FIGURE 2

To understand the role the financing constraint plays in the size of firms, Figure 2 shows the choice of capital for a particular level of the productivity signal  $z$ . Associated with this value of the productivity signal there are two unconstrained capital levels, one for borrowing entrepreneurs,  $k^L(a, z)$ , and another one for depositing entrepreneurs,  $k^D(a, z)$ , with  $k^L(a, z) < k^D(a, z)$ . The straight line  $k^c(a, r^L)$  is the financing constraint (14) which lies above the 45 degree line.<sup>9</sup> Given the value of the productivity signal  $z$ , low levels of accumulated assets make the agent choose to be a worker. As we increase assets we reach a threshold level  $a^s(z)$  at which the agent becomes an entrepreneur. Whether the agent starts being financially constrained depends on the position of the locus  $k^c(a, r^L)$  relative to the level  $k^L(a, z)$  for that particular level of assets. In this Figure, we assume the entrepreneur is constrained so he can only increase capital along the financial constraint. Eventually, he accumulates sufficient assets and, at  $a^u(z, r^L)$ , becomes an unconstrained with the optimal capital level for borrowing entrepreneurs. Maintaining this optimal capital level, he reaches a point of savings at which he can self-finance the project,  $a^{sf}(z, r^L)$ . After this point, the return on capital is between  $(r^L + \delta)$  and  $(r^D + \delta)$ , and the entrepreneur continues to self-finance until he starts depositing at the bank. At this level of assets  $a^u(z, r^D)$  his firm reaches the optimal capital size for the given signal ability shock.

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<sup>9</sup>In the economies with risk sharing or insurance, this schedule will not, in general, be a straight line.

### 6.3 Financing Constraints

In the economy without financial intermediation, the capital-labor ratio for an unconstrained entrepreneur (with  $k < a$ ) is

$$\kappa^u \equiv \frac{k}{n} = \left( \frac{\alpha}{1-\alpha} \right) \left( \frac{w}{\delta} \right).$$

For entrepreneurs who use all assets in production ( $k = a$ ), the financing constraint in equation (12) implies

$$n \leq \left( \frac{1-\delta}{w} \right) a.$$

That is, entrepreneurs with relatively low levels of assets and high skills may be constrained in their choices of inputs. They will exhibit higher capital-labor ratios than unconstrained entrepreneurs and, therefore, larger marginal productivities of capital. Financial intermediation allows these constrained entrepreneurs to enter and/or borrow to expand their firms. On the other hand, unconstrained entrepreneurs with low marginal productivities of capital will deposit and reduce their firms. Eventually, general equilibrium effects will provide incentives for their exit. As higher demand for inputs increases equilibrium prices, profits of low skill entrepreneurs fall below the opportunity cost of forgone current and future wages. The productivity composition of entrepreneurs improves.

Similarly, insurance and risk sharing alleviates the financing constraint of the benchmark economy. Using the fact that only borrowing entrepreneurs are constrained, rewrite the financial constraint for the risk sharing economy (7) for  $z' = \underline{z} = 0$ ,

$$(1-\delta)a + x(1-p)E[y(a, z')|z] - wn - (r^L + \delta)(k - a) \geq 0. \quad (15)$$

As output realizations  $y(a, z')$  are non-negative, the financing constraint is less binding for choices  $x \in (0, 1]$  if the price per one unit of transfer  $p < 1$ . If the price is equal or greater than one, the optimal choice of risk sharing is zero.

The case of insurance contracts is more complicated as input decisions depend on the amount of insurance an entrepreneur is taking. For a given pair of  $(a, z)$  of a borrowing agent, denote the difference in the value of inputs

$$\chi \equiv [wn(a, z) + (r^L + \delta)(k(a, z) - a)] - [wn(\hat{a}, z) + (r^L + \delta)(k(\hat{a}, z) - \hat{a})] > 0,$$

because  $\hat{a} < a$  and inputs are increasing in  $a$  for a given signal  $z$ . Rewrite the financing constraint in equation (11) as

$$\begin{aligned} (1-\delta)a & - wn - (r^L + \delta)(k - a) + \max \{ \underline{y}(\hat{a}, z) + \chi, \chi \} \\ & - (1+p) \int \max \{ 0, \underline{y}(\hat{a}, z) - \hat{y}(\hat{a}, z'|z) \} Q(z, dz') \geq 0, \end{aligned}$$

where  $\hat{y} = \hat{y}(\hat{a}, z'|z)$  are the output realizations at each  $z'$  and  $\underline{y}(\hat{a}, z)$  is the output level that corresponds to the definition of profit in a bad state  $\underline{\pi}(\hat{a}, z)$ .

The financing constraint is less binding if

$$\underline{y}(\hat{a}, z) + \chi > (1 + p) \int \max \{0, \underline{y}(\hat{a}, z) - \hat{y}(\hat{a}, z'|z)\} Q(z, dz').$$

Again, this will be true if the price of the insurance premium and/or the insurance level is not too high. Of course, choosing  $\underline{y}(\hat{a}, z) = 0$  allows the agent to avoid insurance. Because output and  $\chi$  are non-negative, a non-zero insurance contract relaxes the financing constraint.

Each alleviation of the financing constraint increases efficiency. This is because, conditional on a level of wealth, entrepreneurs with a high skill signal  $z$  can enter or expand their firms, while general equilibrium effects provide incentives for low skill entrepreneurs to reduce their firms or exit and become workers. Thus the number of entrepreneurs is decreasing while their skills and size of firms are increasing in the quality of financial markets. In the next Section we show that the two steady states with costly insurance and risk sharing are much more efficient than the benchmark economy.

## 7 Quantitative Results

In this Section we present the results of numerical simulations of four stationary equilibria of the economy without financial intermediation, of the benchmark economy with borrowing and lending, and of the economies with financial intermediation combined with insurance and risk sharing.

### 7.1 Parameters of the Model

Parameters of the model are shown in Table 1 are standard for the U. S. economy as in Cooley (1995). The span of managerial control  $\theta$  set at 0.912, a level close to the one estimated by Burnside (1996). The utility has the logarithmic form.

INSERT TABLE 1 ABOUT HERE

The transition matrix for entrepreneurial skills has important implications for the degree of business persistence and accumulation of wealth by business families. I set the values of  $Q$  and the levels of shocks  $Z$  so that the model is able to replicate the first and second moments of the distribution of wealth. Similarly to Veracierto (2001), we choose the effective ability shocks for the entrepreneurs  $Z = \{0\} \cup [1, \bar{z}]$  with  $Q(\{0\}, \{0\}) = 1$  so that an entrepreneur who fails with the lowest effective ability shock will prefer to be a worker in the following period. Also,  $Q(z, \{0\}) > 0$  for all  $z \in Z$  implies that all entrepreneurs terminate their

businesses in finite time. The entries in the transition matrix are calculated using annualized data from Table 1 in Evans (1987) on growth rates and exit rates of firms in the Small Business Data Base constructed by the Office of Advocacy of the U.S. Small Business Administration (SBA). The workers draw their effective ability shocks from a fixed distribution  $\psi$  with a lowest possible value equal to 0.5. This specification of shocks and their laws of motion imposes the financing constraint in each period and satisfies the assumptions on the existence of a stationary equilibrium.

Productivity parameters are specified so that the outcomes in the financial intermediation economy match the data for the U.S. economy, with entrepreneurs constituting 8% of the population and the average exit rate is around 5% (see Evans (1987)). The discount factor and depreciation rate lead to capital-output ratios equal to 3.89 in the benchmark, 3.23 in the insurance, and 3.16 in the risk sharing steady state, respectively.

The corresponding parameters for the financial intermediaries have been calibrated to match certain statistics of the US banking system. In particular, we were trying to match the fraction of GDP produced by the financial sector, the fraction of capital and labor used in that sector and its capital/output ratio. It is worth noting that, on average, the financial sector is more labor intensive than the rest of the economy. While financial intermediaries use 1.3% of the capital in the economy, they hire 4.2% of the labor force.<sup>10</sup>

The algorithm for finding the steady state of each regime is relatively simple. To solve for the occupational decision, expected values of both options are computed first. We iterate on the wage and the interest rates (and insurance payments) until markets are cleared, banks have zero profit and the conditions of the stationary recursive competitive equilibrium are satisfied. Finally, we set the maximal level of assets high enough so that the upper bound of the stationary distribution of resources is endogenous.

The choice of risk sharing and insurance is expressed as a fraction of the expected profits of each entrepreneur,  $x$ . For the risk sharing contract,  $x \in [0, 1]$  is the fraction of profits subject to risk sharing transfers. For the insurance contract,  $x = \underline{\pi}(a, z)/E[\pi(a, z')|z]$ , where  $\underline{\pi}(a, z)$  is the choice of a profit level below which the entrepreneur receives an insurance transfer and  $E[\pi(a, z')|z]$  is the expected profit.

## 7.2 Steady State Without Financial Intermediation

The aggregate allocations of the economy without financial intermediation are shown in the first column of Table 2. Occupational choice divides the population into entrepreneurs (8%) and workers (92%). As there is no borrowing and lending,

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<sup>10</sup>This data is taken from the Federal Reserve's Flow of Funds Accounts, the Bureau of Economic Analysis Fixed Asset Tables and Employment by Industry.

only 76.9% of aggregate assets are used in production. The capital-output ratio is very high, above five.

INSERT TABLE 2 ABOUT HERE

Table 3 shows the distributional effects of missing financial markets on both occupations: 78% of wealth, 51% of income, and 35% of consumption belongs to entrepreneurs. Average entrepreneur consumes more than six times than the average worker. Correspondingly, the Gini coefficients of wealth and income inequality are very high, 0.94 and 0.51, respectively. The top 5% percentiles of agents own 83% of wealth and receive 48% of income.

Allocations of the median entrepreneur (in terms of wealth) are displayed in Table 4. Entrepreneurs are using almost all their wealth in production. Return on the median firm is 12.3%. Exit from entrepreneurship is a rare event at an average rate 3.5%. While the distribution of firms by employment size is dominated by very small firms (almost a half have fewer than 5 employees), majority of workers are employed by the top decile of largest firms.<sup>11</sup>

We will discuss the efficiency of these allocations in comparison with the other steady states.

### 7.3 Steady State With Financial Intermediation

Financial markets affect agents' incentives to accumulate capital and provide access to credit to agents with low level of accumulated wealth. They allocate resources to individuals where the return is greatest, namely to potential and incumbent entrepreneurs with a high signal ability shock whose projects are profitable on a larger scale than their individual savings allow.<sup>12</sup>

The second column of Table 2 shows that financial intermediation allows all assets to be used in production. The deposit rate is 1.08% and the lending rate is 2.96%. The cost of financial intermediation amounts to only 2.5% of GDP, with a higher share of labor (at 4.1% due to the sector's labor intensity).

The benchmark economy with borrowing and lending reduces the importance of wealth on the occupational decision: the average skill of entrepreneurs increases by 11.7%, the total factor productivity by 19.4%. Table 2 provides another measure of efficiency, an average skill adjusted capital-to-asset ratio,

$$\Omega_E = \int_E \frac{zk(a, z)}{a} \lambda(da \times dz), \quad (16)$$

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<sup>11</sup>For a study of credit constraints in developing countries see an important field study by Paulson and Townsend (2002) who find two-thirds of Thai business households financially constrained, mostly due to a limited commitment problem faced by the poor entrepreneurs.

<sup>12</sup>There is a large literature on the importance of financial markets for general economic activity and economic growth, for example Gertler (1988), Greenwood and Jovanovic (1990), Bencivenga and Smith (1991), King and Levine (1993), or Levine (1997).

which describes the average quality of capital relative to a firm's (entrepreneur's) total assets. In terms of this productivity measure, borrowing and lending is 1.62 times more efficient than the economy without financial markets.

The total output increases by 12.5%. Around 79% of entrepreneurs finance their projects by taking loans with an average leverage ratio 0.48. As talent matters more, turnover between occupations increases, with exit rate now 4.9%, close to the data in Evans (1987) and Davis et al. (1996). Relative to the economy without financial intermediation, the capital-output ratio falls to 3.89.

While financial intermediation allows all assets to be used in production, the aggregate stock is now only 66% of that in the steady state without financial intermediation. These results suggest two possible interpretations. First, financial markets reduce the need for accumulation of assets in order to prepare for starting a firm when an entrepreneurial opportunity arises. Second, the absence of complete insurance markets in the face of idiosyncratic shocks leads to a precautionary demand for assets.

INSERT TABLE 3 ABOUT HERE

Financial intermediation delivers a welfare gain of 17.5%. The main beneficiaries of financial intermediation are workers: Greater competition in the occupation market increases welfare of workers by 41% while that of entrepreneurs falls by 71% (they are still much better off than workers). Compared to the economy without financial markets, the equilibrium wage increases by 43% and there is now a positive return on savings. Both of these represent higher costs to entrepreneurs whose average profits, welfare, and fraction in the population fall.<sup>13</sup>

A more efficient allocation of resources reduces the rent to wealth, with Gini inequality measures decreasing to 0.87 for wealth and especially due to high wages to 0.32 for income. Entrepreneurs now hold only 69% of wealth and 35% of income (numbers still much higher than in the U.S. economy). Occupational choice of heterogeneous agents and the investment decisions of wealth-constrained entrepreneurs is important for matching U.S. distributional data. In particular, saving and investment decisions of entrepreneurs are capable of generating very unequal distribution of wealth.

INSERT TABLE 4 ABOUT HERE

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<sup>13</sup>Self-employment in countries with less developed financial markets high, often close to 50%, mostly in agriculture. Rajan and Zingales (2003) argue and Gine and Townsend (2004) show on Thai data that in an economy with underdeveloped financial markets, incumbent firms enjoy some rents in the markets they operate in, but they also end up appropriating most of the returns from new ventures. These rents might be impaired by financial development, mostly by the entrance of new and more productive firms. This fact suggests a plausible political economy rational for observed financial sector repression.



Table 4 shows that the median entrepreneur’s firm becomes larger and produces more than 30% higher output than the median firm in the economy without financial intermediation. The median entrepreneur has a leverage ratio equal to 0.81 and return 7.9%. Small entrepreneurs borrow from the banks more often than large entrepreneurs, which is also consistent with the data.<sup>14</sup> The share of very small firms with fewer than 5 workers falls to 38%.

## 7.4 Steady States with Insurance and Risk Sharing

Insurance markets might be extremely important for poor entrepreneurs. We analyze the insurance aspect of financial markets in two separate steady states with insurance and risk-sharing. Recall that the ex-ante insurance contract insures a chosen fraction of an entrepreneur’s profit for a premium paid ex-ante, before the actual shock to production is revealed. As the ability to pay the premium depends on an entrepreneur’s wealth, it only partially relaxes the financing constraint. The risk sharing contract does not require a prepaid premium: in this way, it facilitates an unconstrained entry into entrepreneurship. On the other hand, it demands a transfer of funds from the entrepreneur when his project is successful.

Interest rates on deposits and loans increase substantially as assets become more productive. The financial sector is around 5% of GDP, absorbing between 6 and 7 percent of labor force. The capital-output ratio falls further to 3.23 and 3.16, respectively in the insurance and risk-sharing steady states. Average leverage is now 1.50 and 1.97. Table 3 shows that the share of entrepreneurs in deposits decreases with the quality of financial markets. This means that there are fewer entrepreneurs who overaccumulate assets compared to their managerial abilities.

Both insurance and risk sharing further increase the efficiency of capital allocation: by 6% in terms of average skill in entrepreneurship versus the benchmark financial intermediation and 18% versus the economy without financial markets. In terms of total factor productivity, it is around 7% and 28%, respectively. In terms of the skill adjusted capital-to-asset ratio  $\Omega_E$  in equation (16), risk sharing is 1.2 times more efficient than insurance, 2.2 times more than the benchmark steady state, and 3.5 times more efficient than the economy without financial intermediation. As in Moll (2010), the number of entrepreneurs decreases and their productivity increases with the quality of financial markets.<sup>15</sup>

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<sup>14</sup>Arellano et al. (2009) find that firms in countries with more developed financial markets tend to have larger leverage ratios (close to 1.0) and that the leverage-firm size relation is generally downward sloping: small firms have relatively higher leverage ratios than large firms. In the underdeveloped countries, the opposite is true.

<sup>15</sup>OECD and World Bank surveys show that the fraction of self-employed workers in developing countries—where financial markets are also less developed—is much larger than in industrialized countries. These entrepreneurs operate at very low inefficient levels of capital and skills. See also Bloom and Van Reenen (2009) for a survey of management practices across firms and countries.

Table 4 shows that the insurance economy matches the U.S. data for shares of wealth and income held by entrepreneurs (0.40 and 0.21). In this steady state, entrepreneurs hold 9.4 times more wealth than workers, 3.7 times more income and consume 2.2 more. The wealth to income ratio of the median entrepreneur is 4.9. In the risk sharing economy these measures are lower, especially those for assets: entrepreneurs save less because, first, there is no ex-ante insurance premium, and second, successful entrepreneurs must transfer profits back to the risk sharing pool.

With insurance markets, agents in the top wealth percentile own more than 20% of the total wealth and receive 7-8% of the total income. The match with the U.S. data for the top 5% and 10% percentiles of agents is even better. Entrepreneurs are still over-represented in the top percentiles of the wealth distribution. Eight percent of all entrepreneurs come from the top percentile, and majority of entrepreneurs from the top decile of wealth distribution (similar to data collected by Quadrini (1999a)).

Given the increased efficiency, workers' equilibrium wages increase even more, together with their welfare. Risk sharing reduces entrepreneurs' profits due to transfers in all states of the world and thus decreases their average welfare. All relative measures related to entrepreneurs fall as well: their fraction in the population, their share of wealth and income, or return on their projects. In Table 4, the median firm is now twice as big as in the economy without financial intermediation, producing three times more output. Around 70% of firms (both in terms of distribution and employment share) are now concentrated around this median firm size while firms with fewer than 5 workers represent only 2% of all firms.

INSERT FIGURE 3 ABOUT HERE

Figure 3 shows the allocation of capital in production as a function of assets. If allocation of capital were optimal, the allocation of capital would be independent of entrepreneurs' wealth, i.e. it would be a horizontal line. Risk sharing and insurance regimes are the closest to the horizontal allocation, rising only at the top percentiles where wealthy entrepreneurs finance large projects. The benchmark borrowing and lending and especially the economy without financial intermediation show a strong dependence of capital allocation on wealth. The beginning of each represents the entry asset level: insurance and risk sharing allows for entry of very poor entrepreneurs, while the absence of financial markets has the highest switching level of assets. The dots on each line represent deciles of the wealth distribution among entrepreneurs (the last four dots are the 90th, 95th, 99th and 100th percentiles). In the economy without financial markets these top percentiles are extremely wealthy. Insurance and risk sharing markets lead to a more concentrated distribution of wealth.

INSERT FIGURE 4 ABOUT HERE

Figure 4 displays the capital allocation for different signal productivity shocks  $z$  again as a function of wealth with shown percentiles. At given equilibrium prices, the capital allocation is close to optimal for the highest level of shock  $z_8$ . Capital allocation at the lower shock  $z_7$  resembles that of the average entrepreneur while for the next shock  $z_6$ , capital increases in wealth and starts only at the 60th percentile. Notice also that with the ex-ante insurance premium, entrepreneurs with the highest shock are not represented in the bottom two deciles.

INSERT FIGURE 5 ABOUT HERE

Figure 5 shows the degree to which entrepreneurs choose to insure their projects. First, in both insurance and risk sharing steady states, the highest ability entrepreneurs insure the most: in the insurance regime almost half of their profits and almost full profits in the risk sharing regime as their projects and potential losses large. Second, the poor entrepreneurs insure more than entrepreneurs around the median wealth. Finally, the policies are not monotone in wealth: this could be a sign of binding ex-ante premium constraints for entrepreneurs who run larger projects with median wealth.<sup>16</sup>

INSERT FIGURE 6 ABOUT HERE

Policy functions for capital allocation as function of wealth for all steady states are shown in Figure 6 (drawn are policy functions for capital at signal productivities where occupation decision is entrepreneurial). The existence of financial intermediation allows for capital allocation that is greater than assets held by an entrepreneur (policies above the 45-degree line). Depositing entrepreneurs have policy functions below the 45-degree line. The two bottom panels illustrate the difference between insurance and risk sharing: the ex-ante insurance premium limits the size of projects for poor entrepreneurs (upward sloping policies for  $z_7$  and  $z_8$ ), while ex-post risk sharing allows efficient allocation of capital even at the lowest levels of wealth (horizontal policies for the same shocks). Note that agents with  $z_6$  do not borrow and enter when they are self-financing because the cost of borrowing and the opportunity cost of being a worker are too high. In the benchmark economy with borrowing and lending, these self-financed entrepreneurs exist at the next lower level  $z_5$ . Finally, in the economy without financial intermediation even agents with a low signal  $z_4$  are entrepreneurs. These policies document that the entry threshold of  $z$  increases in the quality of financial markets. The pool of entrepreneurs becomes more talented and capital flows to the most profitable projects.

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<sup>16</sup>Entrepreneurs in the insurance steady state and shock  $z_6$  do insure but very little. Their choices of  $x = \pi(a, z_6)/E[\pi(a, z')|z_6]$  are less than -50. For presentation purposes we do not show this line in the Figure. Its shape is similar to the risk sharing policy for the same shock.

INSERT FIGURE 7 ABOUT HERE

Figure 7 shows the capital-to-assets ratios during the entrepreneurial spell of an average entrant. The risk sharing contract allows the average entrant to borrow the most against his assets, closely followed by the insurance contract. The ratio falls quickly during the spell. Basic borrowing and lending without any insurance fares much worse, with the ratio around two for first ten periods of the spell: During these initial periods of entrepreneurship firms operate at very inefficient capital levels. Note that as successful entrepreneurs invest almost a half of their profits, most of them are able to finance their project without borrowing after twenty periods of occupational tenure.

The bottom panels of Figure 8 shows that insurance and risk sharing as a fraction of expected profits decreases in entrepreneurial spell. Entrepreneurs with the highest shock and the highest leverage insure around one half of their expected profits and for the first 10 periods they fully share their risk. The relationship between insurance and spell is not monotone for those with the second highest shock. The insurance taking decreases from very high levels (when their leverage and exposure to large losses is the highest) as agents accumulate assets; it then increases at very long tenures when projects are very large. Again, the ex-ante insurance taking is almost negligible for those with the  $z_6$  and is not shown on the Figure.

INSERT FIGURE 8 ABOUT HERE

This Figure shows that insurance markets are especially important for the most skilled entrants. The price of insurance services is around 0.1 per unit of transfer. The cost of ex-ante insurance represents 8% of average or 11% of median profits (as the premium is actuarially fair and applies only to the set of bad states) while the cost of ex-post risk sharing is much more, 34% and 47%, respectively (as the transfers are paid in all states). This is also the reason why in the insurance steady state accumulates more assets as disposable profits are larger.

Overall, both types of insurance have sizeable effects on the allocation of resources and their distribution. The efficiency gains are large, around one half of those from introducing the benchmark credit markets to the economy without financial intermediation.<sup>17</sup> Our results do not change substantially when insurance is also available to workers.

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<sup>17</sup>Results in Meh (2008) finds these business risk effects much smaller than those of financial constraints. However, in his model the entrepreneurs do not face much risk as the choice of capital is made after observing the productivity shock. This is also the case of Cagetti and De Nardi (2006) and Cagetti and De Nardi (2009).

### 7.4.1 Default, Moral Hazard, and Adverse Selection

We are aware of the fact that the insurance and risk sharing contracts are subject to moral hazard, and for the insurance contracts, also to adverse selection problem (see Cooley et al. (2004) for an excellent example). Indeed, Karaivanov et al. (2006) find that moral hazard is an important source in credit market imperfections.

In our model, if output is unobservable, entrepreneurs might report a lower effective productive shock to the financial intermediary and receive a higher insurance or risk sharing transfer. Similarly, an entrepreneur might be reluctant to deliver a risk sharing transfer to the intermediary if his realized profits are very high. Also, the adverse selection problem is present in the insurance contracts: an entrepreneur might report a higher signal ability  $z$  and pay a lower insurance premium. Entrepreneurs might also default on their loans and/or wages of hired workers.

These contractual problems might preclude some of the insurance and risk sharing contracts we found in our numerical simulations. Since in both insurance and risk sharing economies agents can choose zero insurance or risk sharing, the efficiency gains under asymmetric information will lie between that of the benchmark financial intermediation and those of our full information cases. We plan to analyze our model with asymmetric information and default in our future work.

## 8 Conclusions

This paper shows that financial constraints are important for entrepreneurial entry and firm size decisions. General equilibrium effects related to removing these constraints are large and crucial for the skill composition of entrepreneurs. Finally, borrowing and lending by itself may not be sufficient for the most efficient allocation of capital to entrepreneurial skills. Only when financial markets also insure entrepreneurs against their income risk, the allocation of resources becomes much more efficient.

These results are important for the pivotal role small firms play in innovation, technological change, productivity growth as well as creation of new jobs. Baily et al. (1992) document that about half of the overall productivity growth in U.S. manufacturing in the 1980s can be attributed to factor reallocation from low productivity to high productivity establishments. Restuccia and Rogerson (2008) show that government policies targeting entry of financially constrained and skilled entrepreneurs can have significant impact on occupational choice, efficiency, aggregate levels and the distribution of resources.

Taken together, efficiency of production increases in the quality of financial markets. There are many important issues the paper does not address. Our framework can be used to study the effect of technology innovations on entry and

exit into entrepreneurship. Jermann and Quadrini (2003) analyze the impact of technology innovations in a similar model with heterogeneous firms and limited enforceability of financial contracts. Financial intermediation can be modeled in a greater detail: The banks could optimally provide multiperiod loans, break even only in expectation, or require collateral that fits the needs and characteristics of the entrepreneurs. Finally, we plan to address the issue of default, moral hazard, and adverse selection in our future work.

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Parameters							
	$\beta$	$\alpha_E$	$\alpha_B$	$\theta$	$\delta$	$Z_B$	$\sigma$
	0.965	0.32	0.15	0.912	0.043	35.0	1.0
Ability Shocks $Z = \{z_1, \dots, z_8\}$							
0	1.00	1.25	1.50	1.75	2.00	2.25	2.50
Distribution $\psi$ of Workers' Ability Shocks							
0.10	0.70	0.08	0.06	0.03	0.02	0.01	0
Transition Matrix $Q$ for Entrepreneurs' Ability Shocks							
1	0	0	0	0	0	0	0
0.109	0.698	0.192	0.001	0	0	0	0
0.059	0.095	0.713	0.131	0.002	0	0	0
0.053	0.001	0.111	0.736	0.098	0.001	0	0
0.044	0.004	0.015	0.107	0.755	0.074	0.001	0
0.039	0	0	0.001	0.162	0.756	0.041	0.001
0.025	0	0	0	0.008	0.172	0.758	0.037
0.018	0	0	0	0	0.001	0.339	0.642

Notes: Workers' lowest ability shock  $z_1 = 0.5$ .

Table 1: Parameters of the model.

Steady States				
Average	No F.I.	Financial Intermediation		
		Benchmark	Insurance	Risk Sharing
Entrepreneurs	8.0%	7.8%	6.6%	6.5%
Assets	6.90	4.56	3.79	3.65
Capital				
Production	5.31	4.44	3.67	3.52
Financial	—	0.12	0.12	0.13
Output	1.04	1.17	1.19	1.17
Welfare	0.80	0.94	0.97	0.96
Equilibrium Prices				
Wage $w$	1.03	1.47	1.59	1.59
Deposit Rate $r^D$	—	1.08	2.57	2.78
Loan Rate $r^L$	—	2.96	4.88	5.06
Price of Insurance $p$	—	—	0.10	0.11
Capital-Output	5.09	3.89	3.23	3.16
Leverage	—	0.48	1.50	1.97
Insurance/Assets	—	—	0.02	0.06
Insurance/Income	—	—	0.08	0.34
Borrowers (%)	—	79.3	74.6	77.1
Spell	26.1	20.6	13.0	12.8
Exit Rate	4.1%	4.9%	8.2%	8.2%
Efficiency				
Average Entr. Skills	1.79	2.00	2.12	2.12
TFP	1.29	1.54	1.64	1.65
Capital Skill / Assets*	1.78	2.90	5.26	6.29
Share of the Financial Intermediation Sector**				
Capital	—	0.020	0.032	0.036
Labor	—	0.041	0.064	0.070
Output	—	0.025	0.047	0.054

Notes: ‘No F.I.’ is the steady state without financial intermediation. Output in the goods sector only. \*Capital Skill / Assets is defined as the product of entrepreneurial skill and capital in production divided by assets held by the entrepreneur. \*\*Includes the insurance sector (the share of insurance in GDP is less than one percent, 0.004, the share of risk sharing is 0.006).

Table 2: Steady states.

Distribution and Entrepreneurs				
Average	No F.I.	Financial Intermediation		
		Benchmark	Insurance	Risk Sharing
Welfare	0.80	0.94	0.97	0.96
Workers	0.56	0.79	0.90	0.90
Entrepreneurs	3.58	2.51	1.96	1.77
Gini Measure of Inequality				
Wealth	0.94	0.87	0.81	0.77
Income	0.51	0.32	0.25	0.23
Asset Percentiles				
Top 1%	0.44	0.32	0.23	0.20
Top 5%	0.83	0.70	0.59	0.53
Top 10%	0.96	0.85	0.76	0.70
Top 20%	0.98	0.93	0.86	0.82
Top 40%	0.99	0.95	0.93	0.91
Income Percentiles				
Top 1%	0.25	0.13	0.08	0.07
Top 5%	0.48	0.30	0.21	0.19
Top 10%	0.56	0.39	0.30	0.28
Top 20%	0.68	0.47	0.40	0.39
Top 40%	0.87	0.83	0.56	0.56
Entrepreneurs Share in Total				
Assets	0.78	0.69	0.40	0.33
Income	0.51	0.35	0.21	0.19
Consumption	0.35	0.23	0.13	0.12
Deposits	—	0.12	0.05	0.04

Notes: ‘No F.I.’ is the steady state without financial intermediation.

Table 3: Distribution and Entrepreneurs.

<b>Median Entrepreneur</b>				
Median	No F.I.	Financial Intermediation		
		Benchmark	Insurance	Risk Sharing
Assets	30.1	19.6	13.7	9.7
Capital	30.0	35.5	52.8	59.7
Labor	5.2	7.3	13.0	15.0
Output	6.3	9.4	16.6	19.4
Profit	3.7	2.9	2.8	2.8
Return	12.3%	7.9%	5.3%	4.7%
Capital-Output	4.76	3.78	3.18	3.08
Leverage	—	0.81	2.85	5.15
Insurance/Assets	—	—	0.02	0.13
Insurance/Profit	—	—	0.11	0.47
Spell	18.4	14.2	8.3	8.2
Exit Rate	3.5%	5.3%	8.6%	8.6%

Notes: Median entrepreneur in terms of wealth. ‘No F.I.’ is the steady state without financial intermediation.

Table 4: Median Entrepreneur.

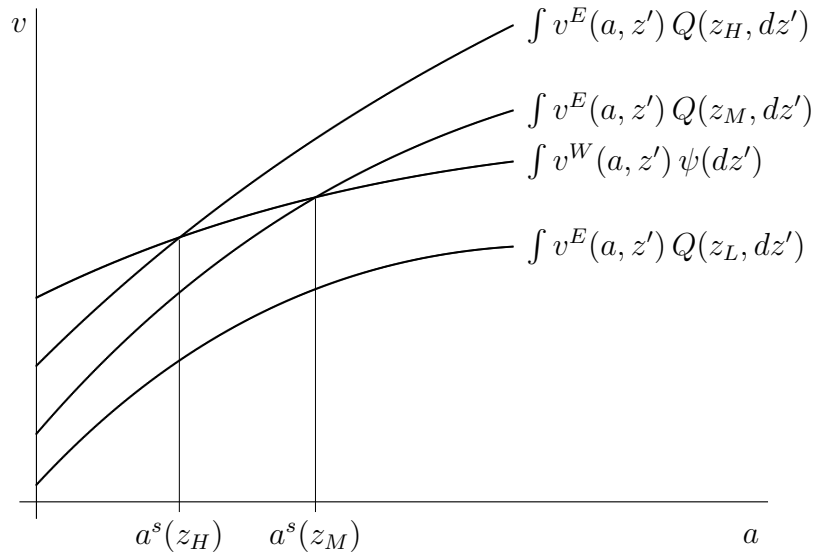


Figure 1: Value functions of entrepreneurs and workers.

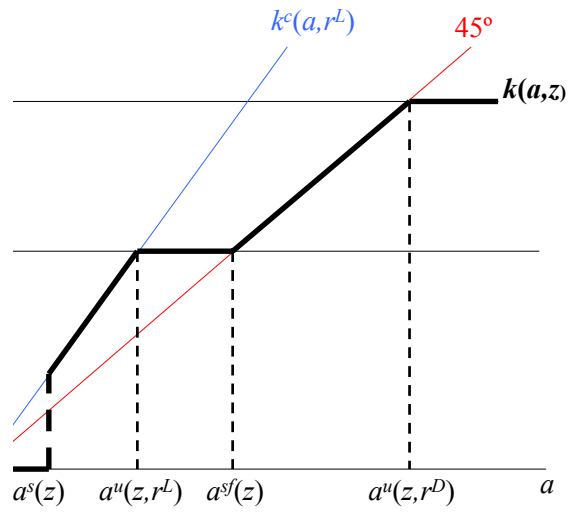


Figure 2: Policy function for capital allocation as a function of wealth and skill.

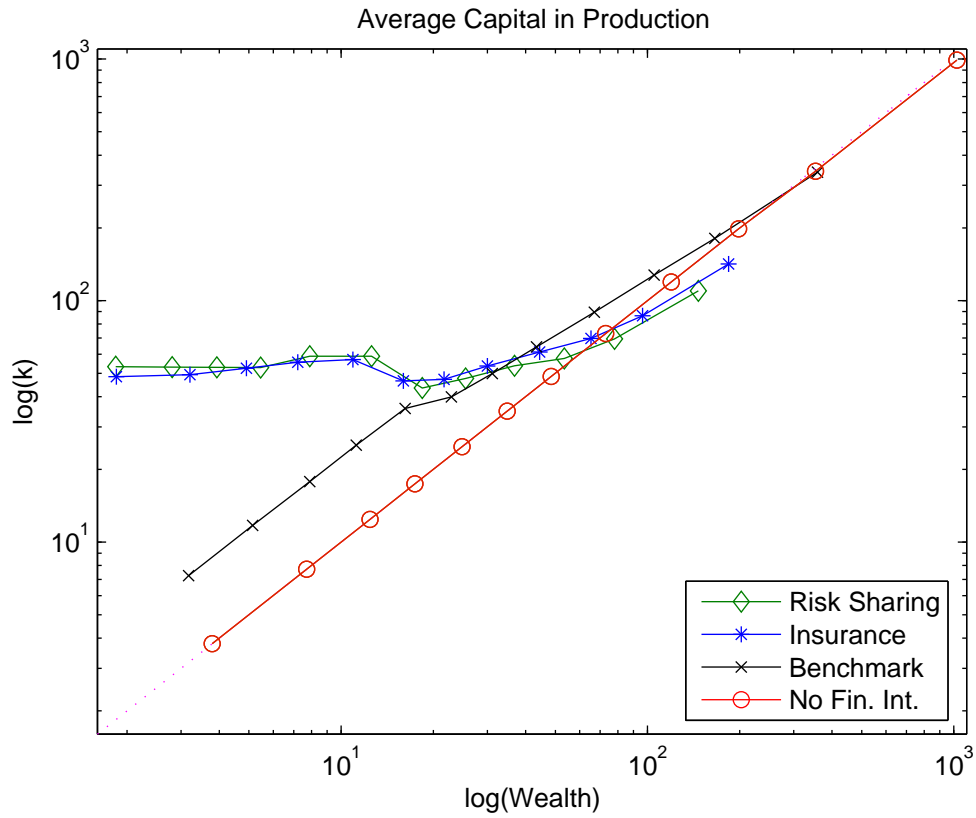


Figure 3: Average capital in production as a function of entrepreneurial wealth. Dots represent deciles of the entrepreneurial distribution of wealth (1st, 2nd, ...) with the last four dots denoting the 90th, 95th, 99th, and 100th percentile, respectively.



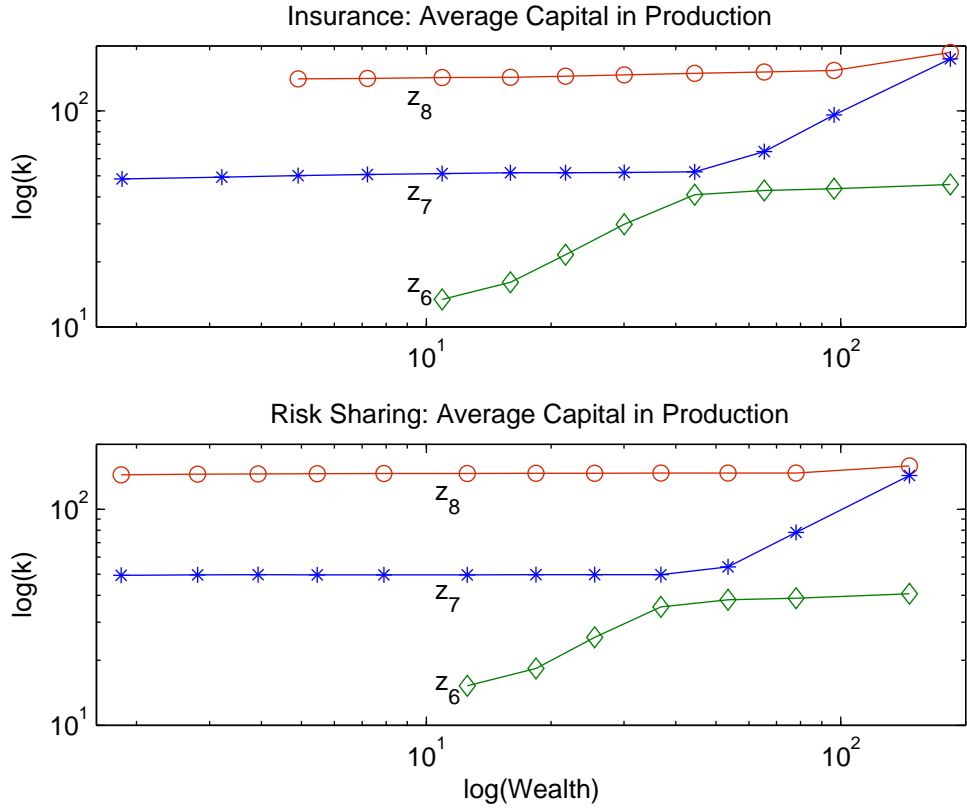


Figure 4: Capital in production for different productivity signals  $z$  as a function of entrepreneurial wealth. The dots represent deciles of the entrepreneurial distribution of wealth (1st, 2nd, ...) with the last four dots denoting the 90th, 95th, 99th, and 100th percentile, respectively.

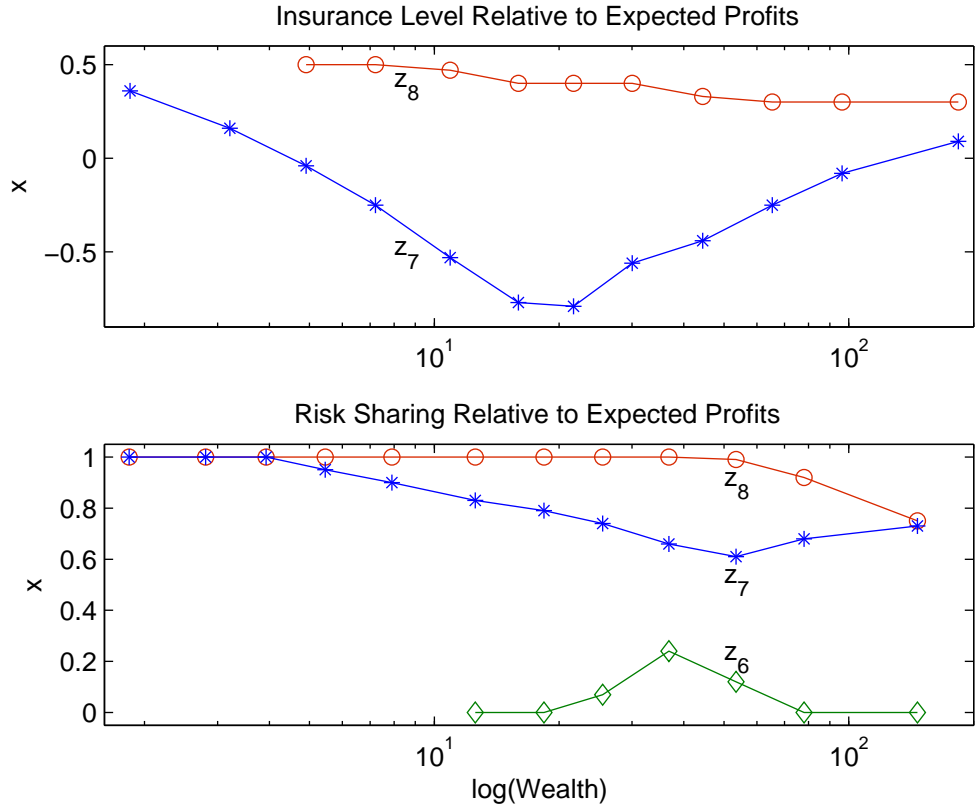


Figure 5: Insurance and risk sharing for different productivity signals  $z$  as a function of entrepreneurial wealth. The dots represent deciles of the entrepreneurial distribution of wealth (1st, 2nd, ...) with the last four dots denoting the 90th, 95th, 99th, and 100th percentile, respectively.

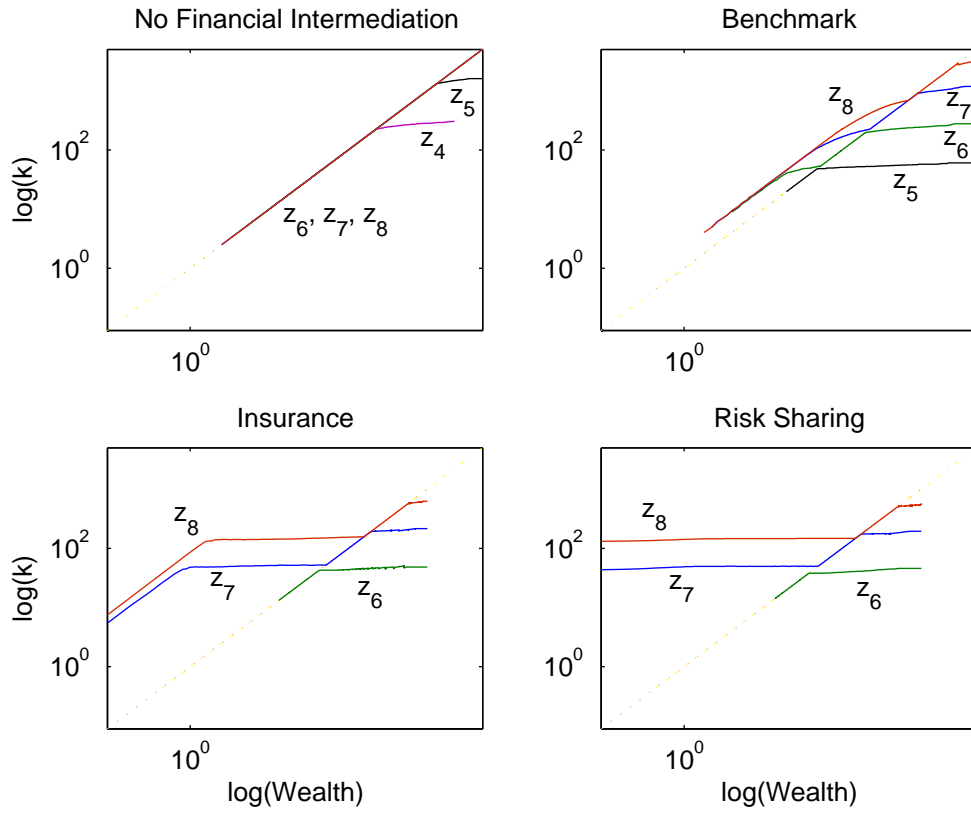


Figure 6: Capital in production for different productivity signals  $z$  by entrepreneurial wealth. Policy functions conditional on agents' being entrepreneurs.

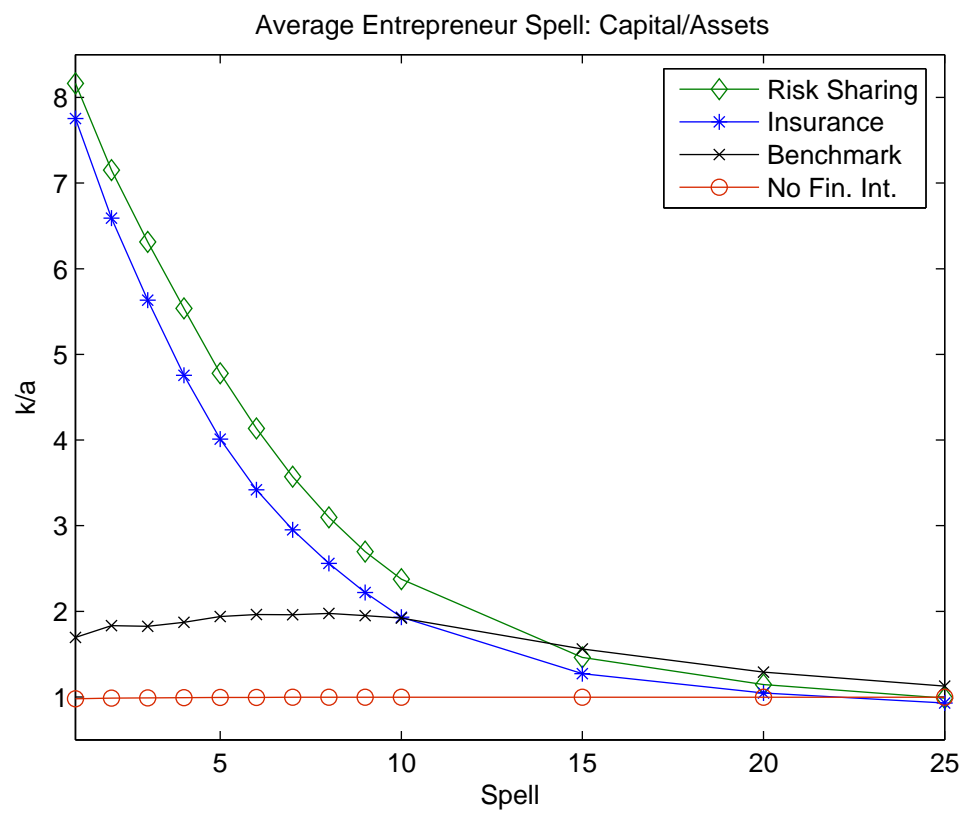


Figure 7: Ratio of capital in production to assets during an average entrepreneurial spell.

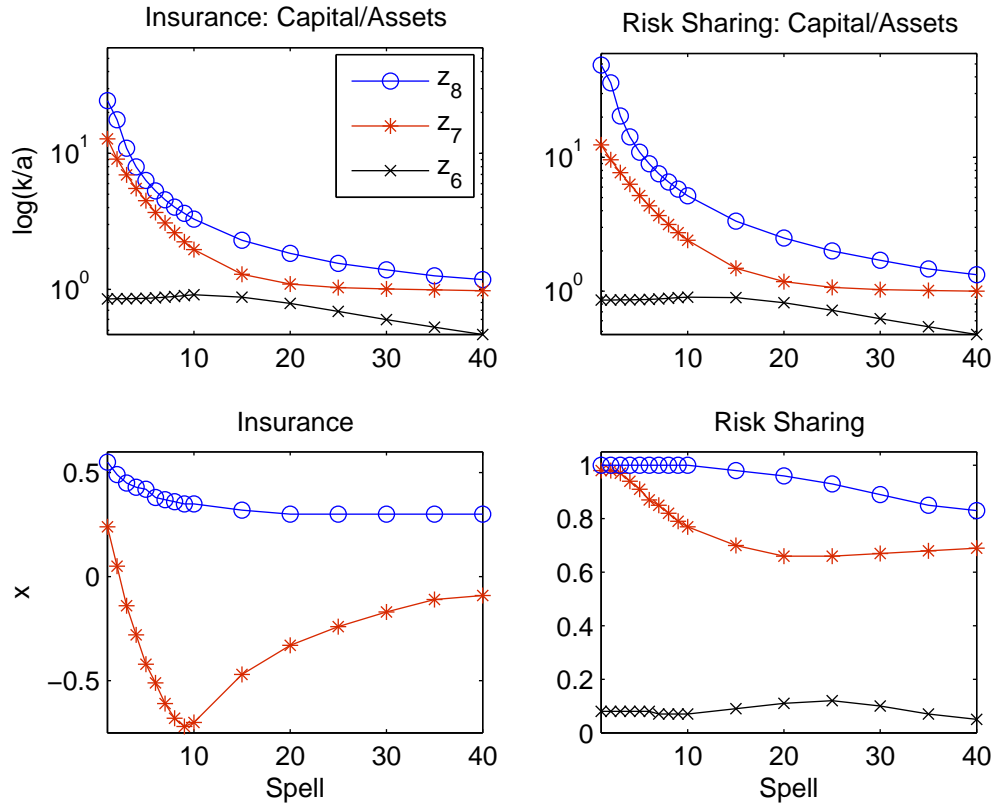


Figure 8: Ratio of capital in production to assets and insurance during average entrepreneurial spells for different productivity signals  $z$ .